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Nighttime Nurturing: An Evolutionary Perspective on Breastfeeding and Sleep

Helen L. Ball and Charlotte K. Russell

Introduction

When considering the nighttime needs of mothers and babies, an anthropological vantage point provides a unique perspective on “human nature” by employing both phylogenetic depth and cross-cultural breadth to expose a variety of tensions between contemporary infant care and maternal and infant evolved biology. This chapter examines mothers’ and babies’ needs with regards to feeding, sleeping, and nighttime care and begins by drawing comparisons in infant care across humans and other mammals. This comparative phylogenetic perspective defines three things: (1) those traits of human mothers and infants that are common to all mammals, (2) those that are shared only with our closest primate relatives, and (3) those that are unique to the evolution of our species. A comparative historical and cross-cultural perspective can then help identify infant care practices that are adaptations to more recent ancestral environments and those that are historically novel cultural developments within particular societies. Cultural adaptations to recent ancestral environments would be infant care practices such as the use of the cradleboard or Peruvian manta pouch for transporting and securing infants in cold environments, compared with the use of carrying slings and bags in tropical environments.

The comparative phylogenetic approach also reminds us that when contemplating aspects of human nature with deep evolutionary roots, a single ancestral environment (AE) does not exist; in framing our potential AEs we must consider both shifting selection pressure over time and intersection with ancestral cultural adaptations (ACA). The first relevant AE in this example (AE-1) relates to the fundamental biology and behavior of humans as placental

mammals involving the production of relatively well-developed live-born young who require postnatal maternal care and lactation (the defining characteristic of the *Mammalia*; Pond, 1977).

Length of gestation period and developmental state at birth vary among mammals, with infants generally categorized into two well-known types. Altricial newborns are poorly developed, sequestered in nests, and fed infrequently with high-fat milk. Precocial newborns are well developed, able to follow or cling to their mothers, and suckle frequently and at will on milk that is relatively low in fat but high in calories (lactose), providing energy in a quickly digested form (Small, 1998). Among the primates, monkey and ape infants are precocial; human infants conform, by consequence of evolutionary relatedness, to this precocial primate pattern (AE-2).

Yet human infants also display “secondarily altricial” characteristics—primarily lack of neuromuscular control—a consequence of the limits imposed on gestational brain development by the evolution of the human pelvis. Human newborn brains are 25% of their adult volume (compared to 50% for infant chimpanzees and gorillas) due to the constraints of a birth canal that was modified for bipedal walking. Although displaying many precocial traits, therefore, human infants are unable to independently locomote or cling, and therefore maintain proximity with their mothers, or to effectively regulate temperature and breathing during the first few months of rapid brain growth and development (AE-3; Hrdy, 1999; Small, 1998).

Human milk has a similar composition to that of other precocial primates, being relatively low in fat and protein but high in sugar (Jelliffe & Jelliffe, 1978). It is milk produced for infants (AE-1) who suckle frequently and of their own volition day and night (AE-2), and the high sugar content in the case of humans provides the energy needed for rapid brain growth. Due to poor neuromuscular control, however, human neonates require

their mothers to ensure that proximity is maintained, frequent feeding facilitated, and physiology regulated (AE-3). Ethnographic data from societies around the world confirm that mothers in traditional human societies are in almost constant contact with their infants, carrying them strapped to their bodies by day, sleeping beside them at night (Ball, 2007), and breastfeeding at will. Consideration of the human neonate from an evolutionary perspective therefore highlights the fact that many aspects of what is considered to be “normal infant care” in contemporary Western societies are historically recent culturally adopted practices (Crawford, 1994).

Since the mid-1930s, for instance, prolonged and independent nighttime sleep has been the hallmark of a “good baby” in many Western societies; early infant independence has been viewed as a developmental goal, and its achievement as a measure of effective parenting (e.g., Javo, Ronning, & Hyerdahl, 2004; Valentin, 2005). Yet for the majority of the world’s cultures, separation of an infant from its mother for sleep is considered abusive or neglectful treatment (Jenni & O’Connor, 2005; Morelli, Rogoff, Oppenheim, & Goldsmith, 1992), for which Westerners are criticized. In the United States and United Kingdom, separate sleep locations for parents and infants in the household are historically recent—less than two centuries ago mother–baby sleep contact was the norm (Hardyment, 1993). Two particularly influential new cultural environments (NCE) emerging during the 19th and 20th centuries gave rise to rapid and dramatic introduction of novel infant care practices (NICPs): the medicalization of childbirth and the emergence of “scientific motherhood” (Hardyment, 1993; Hulbert, 2003); principal among the novel practices introduced in response to these new cultural environments was the decoupling of infant feeding and sleeping from the mother’s body (Hardyment, 1993; see Figure 9.1).

<Figure 9.1 Here>

Medicalization of Childbirth [New Cultural Environment-1 NCE-1])

One consequence of AE-3, when brain size increased following pelvic constriction, was that childbirth became a hazardous and liminal activity with unavoidably high rates of maternal and infant deaths associated with the birth process throughout human history (Loudon, 1993). By the Victorian era, interventions to ease the fear of pain and death in childbirth were becoming popular (Loudon, 1993; Tew 1995). The use of chloroform, the anesthetic of the day, was restricted to hospital settings; women increasingly chose to deliver their babies in hospitals to avail themselves of anesthesia, even though chloroformed mothers were unable to care for their babies while recovering from the effects of the gas. Due to maternal incapacitation, nurseries were established in hospitals and babies were cared for by nursing staff (Tew, 1995). Efforts to improve the experience of childbirth for women (NCE-1a) therefore had serious and unanticipated repercussions for early infant care and mother–infant relationships, leading to popular acceptance of mother–newborn separation as normative behavior (NICP-1). Subsequent generations of anesthetics such as twilight sleep and intravenous barbiturates (Pitcock & Clark, 1992; Tew, 1995) also incapacitated women during and following delivery; recovery was a long process and infant care was impossible. Twilight sleep and barbiturates also affected infants, who were born sleepy and unable to respond or suck, many being force-fed in the first days after birth. Even respiratory movements were suppressed, and babies in the nurseries had to be monitored carefully (Feldhusen, 2006). From the 1940s, when aseptic practices and sulphur antibiotics were introduced into clinical practice and hospital birth mortality rates declined, the proportion of hospital births increased exponentially, reaching a zenith in 1973 when 99% of all US births took place in a hospital under the control of a physician (Nusche, 2002). The separation of mothers and infants following birth (NICP-1) was now routine. Campaigns to reduce medicated childbirth, such as those spear-headed by Grantley Dick-Reed and Fernand Lamaze, reduced narcotic use in labor throughout the 1950s and 1960s (Feldhusen, 2006;

Nusche, 2002; Tew, 1995); however, the continued transfer of neonates to the hospital nursery was now justified with reference to infection control (NCE-1b). Although mothers were no longer incapacitated, babies were “removed to a safe place” for observation, and mothers were encouraged to rest following delivery—viewing their infants through glass partitions and meeting them only at scheduled feeding times (Hock, McBride, & Gnezda, 1989).

The Application of Science to Infant Care (New Cultural Environment-2 NCE-2)

While the medicalization of childbirth created one new cultural environment in which novel infant care practices arose, the application of science to infant care created another (NCE-2). The legacies of “experts” such as Holt, Watson, Freud, and Skinner in persuading parents that infant care should conform to rigid schedules, involve minimal touching and cuddling, eschew breastfeeding as an inappropriately sexualized activity, and promote independence by refusal to respond to crying had consequences reaching into the present day (Apple, 1995; Hardymen, 1983; Hulbert, 2003). The development and promotion of “scientifically formulated” infant food (NCE-2a) have been well documented (Apple, 1995; Hulbert, 2003) and played an important role in keeping infants alive during their mothers’ “absence” in the context of the NCE-1a. However, even once the after-effects of labor and delivery anesthesia had subsided, physicians advocated feeding infants via artificial formula so that their food intake could be “scientifically managed.” Arguably the most negative outcome of the near-universal uptake of hospital births, medicated deliveries, and mother–newborn separation was the fall in the proportion of mothers initiating breastfeeding. In the United States and Western Europe, breastfeeding rates (which had once been almost universal) fell dramatically to a nadir of 20–22% initiation rate in the United States between 1956 and 1972 (Wright, 2001). The acceptance of “scientific motherhood,” combined with the influx of women into the

industrial workforce in the era of World War II, led to the massive popularity of artificial formula for infants in the mid-20th century and cemented a second cultural shift in infant care (NICP-2) with further unforeseen ramifications.

In the 1940s, when sleep researchers Moore and Ucko (1957) began systematically documenting the developmental pattern of infant sleep, tables enumerating an infant's month-by-month sleep requirements were *de rigueur* (Good Housekeeping, 1956 ; Hardymont, 1983). Moore and Ucko's data became regarded as the yardstick against which infant sleep development should be assessed. Seventy percent of the 160 babies they studied commenced settling by 3 months of age—and it soon became the advice of pediatricians and the goal of parents that infants should “settle” (begin sleeping through the night, defined as midnight to 5 a.m.) by 3 months of age (NCE-2b; e.g., Better Homes and Gardens, 1965). Although Moore and Ucko recognized that feeding type (breast milk or formula) had an impact on infant sleep behavior, the establishment of prolonged and early sleep habits were their principal priority: “Unsatisfactory feeding is generally the first thing to be looked for in a wakeful baby. . . . Where breast feeding proved unsatisfactory, weaning to a bottle or complementary feeds sometimes had an immediate beneficial effect on sleep; in other cases, strengthening the formula or introducing solids settled the child” (p. 338). As decades passed the pursuit of early and unbroken sleep in young infants became a parental priority, and expectations regarding the normal pattern of infant sleep development were culturally codified in pediatric and parenting manuals; the second sentence of the American Academy of Pediatrics' *Guide to Your Child's Sleep* (Cohen, 1999) states, “In early infancy, the first task is to help your baby learn to sleep longer at night . . .” (25, p. 1). Hundreds of books, magazine articles, and Internet sites extol myriad techniques for achieving a somnolent baby. However, it is now apparent that Moore and Ucko's infant population was predominantly composed of formula-fed infants and that they recorded artificially premature settling (consolidation of nighttime

sleep) of their subjects, in part due to the soporific effects of cow's milk and in part due to the separation of infants at night from their mothers, who underestimated their infant's night waking (Anders, 1979). However, the notion of these developmental milestones for infant sleep are now cemented in parenting folklore as targets to be attained and consequently give rise to conflict between parental efforts to ensure that infants sleep through the night at as early an age as possible (NICP-3) and the biological requirement for breastfed infants to wake and feed frequently throughout the day and night (Carey, 1975; Quillin & Glenn, 2004; Wright, MacLeod, & Cooper 1983; Zuckerman, Stevenson, & Bailey, 1987).

The differences in sleep patterns between breastfed and formula-fed infants arise largely as a consequence of the human infant's inability to easily digest cow's milk (Raphael, 1976), which can cause formula-fed infants to sleep more deeply and for longer periods at an earlier age than breastfed infants (Butte & Jensen, 1992; although see Doan, Gardiner, Gay, & Lee, 2007). Infant sleep bouts gradually consolidate into a diurnal rhythm over the course of the first year of life, but breastfed infants—particularly those who are exclusively breastfed for at least 6 months in accordance with current health guidelines (World Health Organization, 2003)—do not experience consolidation of nighttime sleep as early as their formula-fed counterparts (Carey, 1975). Additionally, infants fed artificial formula exhibit significantly different sleep patterns compared with breastfed infants in terms of shorter sleep latency (time taken to fall asleep), longer duration of rapid eye movement (REM; active) sleep, and a larger percentage of REM, while breastfed infants experience significantly more sleep interruptions during the night, are fed more frequently, and consequently have significantly more night feedings (Elias, Nicolson, Bora, & Johnston, 1986). The “. . . development of a long unbroken night's sleep by the early age of 4 months is surprising when considered from an evolutionary viewpoint, because human infants, like other primates, are physiologically adapted for frequent suckling and close physical contact with their mothers”

(Elias et al., 1986 p. 322). Unrealistic ideals for infant sleep continue to undermine the confidence of new parents regarding their infants' normal development. For those committed to breastfeeding, sleeping with their babies (i.e., conforming to the “precocial mammalian pattern” of the AE-2) is one of the means by which mothers ameliorate frequent nighttime feeding and later settling (Ball, 2002; McCoy et al., 2004; Morgan, Groer, & Smith, 2006).

Consequences of Novel Infant Care Practices on Breastfeeding, Lactation, and Sleep

Breastfeeding

Postpartum separation of mothers and babies (NICP-1) and artificial infant feeding (NICP-2) were unprecedented and untested interventions in human reproductive biology and behavior. They subjected Euro-American mothers and infants to experiences that contrast markedly with the close and prolonged postnatal contact of mothers and infants across the anthropoid primates, and across human societies worldwide (Barry & Paxson, 1971; Small, 1998). The results of Harlow's research with infant monkeys dramatically demonstrate the importance for infants of 24-hour physical contact with their mothers' bodies—even when the mother is an inanimate cloth-covered surrogate (Blum, 2002; Harlow, 1959). Subsequent clinical studies regarding the effects on infants of separation from their mothers confirms the importance of close physical contact—not just in terms of psychological development, but also in terms of basic physiological functioning (Anderson, Moore, Hepworth, & Bergman, 2003; De Chateau & Wiberg, 1977; Righard & Alade, 1990; Varendi & Porter, 2001) for both infant and mother (Uvnas-Moberg, 2003).

When, in the 1980s, research began to demonstrate the detrimental consequences to both maternal and infant health of feeding babies with artificial formula (Cunningham, Jelliffe, & Jelliffe, 1991; Dewey, Heinig, & Nommsen-Rivers, 1995; Howie, Forsyth, Ogston,

Clark, & Florey, 1990), mechanisms were sought to reverse the breastfeeding decline, and it soon became apparent that mother–infant separation in the postbirth period undermined both breastfeeding and lactation (Anderson et al., 2003). As a consequence, the past two decades have witnessed a renewed recognition of the importance of close contact for mothers and babies and increasing rejection of NICP-1 and NICP-2.

In the immediate postnatal period, human infants born following an unmedicated labor and placed directly onto their mothers' abdomens exhibit innate nipple-seeking behavior (Righard & Alade, 1990), during which they crawl and squirm up their mothers' bodies, guided to the nipple by smell (Nissen et al, 1995; Varendi & Porter, 2001; Varendi, Porter, & Winberg, 1994); locate the nipple by head bobbing; and spontaneously latch and suckle without assistance (Varendi et al., 1994) over the first hour of life. Infants delivered following a medicated labor involving opioid analgesics make little or no attempt to crawl, and those that try are disorganized, uncoordinated, and unsuccessful in gaining the nipple (Ransjo-Arvidson et al., 2001; Righard & Alade, 1990). Unmedicated infants perform an instinctive pattern of hand movements during nipple seeking that is associated with an increase in maternal oxytocin levels and is similar to those observed in other mammals where massage of the mammary tissue facilitates milk let-down (Matthiesen, Ransjo-Arvidson, Nissen, & Uvnas-Moberg, 2001). Mothers and babies who experience unhurried skin-to-skin contact immediately following delivery, during which time these behaviors can unfold, have a far greater chance of both establishing successful breastfeeding and having prolonged breastfeeding duration (Andersen et al., 2003; Johnston & Amico, 1986; Uvnas-Moberg, Widstrom, Werner, Matthiesen, & Winberg, 1990).

Mother–Infant Sleep Contact

By the end of the 20th century, recognition of the importance of breastfeeding to infant health, and the role of separation in preventing the effective establishment of breastfeeding,

led to the closure of newborn nurseries in many European hospitals (e.g., Sweden, United Kingdom), although the United States still lags behind (Young, 2005). With the closure of nurseries came a shift to mothers and babies “rooming-in,” with the baby located at the mother’s bedside during the day but removed to a communal nursery at night or (more recently) 24-hour rooming-in with mothers performing all aspects of their infant’s care. Comparison of the effects of rooming-in with nursery care found that separation of infants to neonatal nurseries resulted in less frequent breastfeeding (Yamauchi & Yamanouchi, 1990) and greater likelihood of breastfeeding failure (Uvnas-Moberg et al., 1990), but no increase in maternal sleep or alertness (Keefe, 1988; Waldenstrom & Swenson, 1991). Infants who spent their nights in nurseries were also found to sleep significantly less and to cry more than those at their mothers’ bedside (Keefe, 1987). The evidence concerning the impact of mother–baby separation on breastfeeding drives the current cultural changes that emphasise skin-to-skin contact following delivery and rooming-in on the postnatal ward (NCE-3; DiGirolamo, Grummer-Strawn, & Fein, 2001; Perez-Escamilla, Pollitt, Lonnerdal, & Dewey, 1994; UNICEF UK, 2000; World Health Organization, 1999).

Given the importance of close contact in establishing breastfeeding and the need for frequent suckling to promote continued lactation, anthropologists consider mother–infant sleep contact to be a normal, species-typical parenting behavior for humans. Over the past two decades, research into infant sleep behavior in postindustrial contexts has revealed that, contrary to earlier assumptions (Davies, 1994), parent–baby sleep contact is a common form of nighttime care (see Fig 9.2). Bed-sharing prevalence in the United Kingdom (ever sleeping with baby in the same bed) is around 50% among 1-month-old infants, dropping to 25–29% at 3 months old (Ball, 2003; Blair & Ball, 2004; Bolling, Grant, Hamlyn, & Thornton, 2007; Greenslade, 1995), and a baseline bed-sharing prevalence of 40–50% among neonates has subsequently been replicated around the world, indicating that parent–infant sleep contact is

common in a wide variety of Western countries. Repeatedly in these studies researchers have found a strong association between sleep contact and breastfeeding (Ball, 2003; McKenna, Mosko, & Richard, 1997), with mothers identifying “ease and convenience of breastfeeding” as their overwhelming reason for keeping their infants close at night.

<Insert FIGURE 9.2 HERE>

In locations such as the United States and United Kingdom, where breastfeeding has not been the cultural norm for a generation or more and new mothers are often unprepared for the frequency with which their breastfed newborns need to feed or how long nighttime breastfeeding is likely to continue (Ball, 2003; Bolling et al., 2007, Greenslade, 1995), studies report that frequent night waking is a factor contributing to the introduction of artificial formula to babies, thereby undermining breastfeeding (Marchand & Morrow, 1994; Pinilla & Birch, 1993). In the United Kingdom, we observed that babies who bed-shared were twice as likely to be breastfeeding at 4 months of age, compared to babies who were initially breastfed but did not bed-share (Ball, 2003). It was unclear, however, whether mothers with a commitment to long-term breastfeeding were predisposed to bed-sharing at the outset—or whether there was an underlying connection that linked bed-sharing with breastfeeding continuation. McKenna’s previous research indicated that when babies bed-share they suckle more frequently at night than when sleeping alone (McKenna, Mosko, & Richard, 1997).

Lactation

As frequent suckling is associated with the successful establishment of breastfeeding, we hypothesized that sleeping in close proximity following delivery (i.e., continuation of partial skin-to-skin contact for the duration of the postnatal ward stay) may have the potential to enhance breastfeeding establishment and continuation. To explore this we conducted a randomized controlled trial in a tertiary-level UK hospital (details of the trial protocol can be

found in the clinical report; Ball, Ward-Platt, Heslop, Leech, & Brown, 2006). Overnight videos were made of mother–baby dyads randomized to three sleep locations for their postnatal ward stay: (1) baby in the standard bassinette at mother’s bedside, (2) baby in a side-car crib attached to mother’s bed, and (3) baby in mother’s bed with rail attached to bedside—known as the bassinette, side-car, and bed conditions, respectively. We found that babies in the bed or side-car crib had more frequent attempted and successful feeds than those infants in the bassinette, with no significant differences found in feeding frequency measures between the bed and side-car conditions (Ball et al., 2006). Video data demonstrated that the stand-alone bassinette impeded breastfeeding by introducing a barrier between mother and baby, preventing contact; inhibited the baby’s ability to effectively root and initiate suckling; obscured the baby’s feeding cues from the mother; and by its height prevented mothers from retrieving their babies without either assistance or the need to get out of bed, thereby substantially hampering the ease and speed of maternal response (Ball et al., 2006; Ball, Ward-Platt, Howel, & Russell, 2010; Klingaman, 2010).

Prompt response to babies’ feeding signals and frequent suckling in the early neonatal period are essential in ensuring successful milk production—a process controlled by prolactin (Johnston & Amico, 1986; Uvnas-Moberg et al., 1990). Babies trigger maternal prolactin surges with every feed attempt, so frequent attempts are key. Facilitating close contact at night is especially important because night feeds trigger greater prolactin release than day feeds (Tennekoon, Arulambalam, Karunanayake, & Seneviratne, 1994; Woolridge, 1995). The amount of prolactin released and the frequency of prolactin secretion following birth are associated with earlier lactogenesis II and increased milk production (Chapman & Perez-Escamilla, 1999; Neville, Morton, & Umemura, 2001; Sözmen, 1992).

Prolactin therefore links mother–infant sleep contact with improved breastfeeding initiation (Ball, 2008). Elevation of initial prolactin levels is also implicated in successful

long-term lactation. The maintenance of lactation is dependent on the development of prolactin receptors in breast tissue (Riordan & Auerbach, 1993), which also result from frequent feeding in the early days after birth (Marasco & Barger, 1999) and are thought to be crucial in maintaining lactation following the switch from endocrine to autocrine control of milk production (Lawrence & Lawrence, 1999). We hypothesized, therefore, that frequency of early feeding attempts would be associated with breastfeeding duration. A common reason given by women for stopping breastfeeding is a perceived or real insufficiency in breast milk production (Bolling et al., 2007), suggesting inadequate prolactin receptor development in the initial phases of breastfeeding. As those infants sleeping in close proximity to their mothers on the postnatal ward in the trial described previously (bed or side-car crib) fed more frequently than infants randomly allocated to the stand-alone bassinet, we compared their long-term breastfeeding outcomes using data obtained via telephone interviews at 2, 4, 8, and 16 postnatal weeks. Although all mothers initiated breastfeeding on the postnatal ward, at 16 weeks 43% of babies who were in a separate bassinet on the postnatal ward were still breastfeeding, compared with 73% of the crib group and 79% of the bed group (Ball, 2008). Mother–infant sleep contact in the early neonatal period therefore promotes successful breastfeeding initiation and earlier lactogenesis II and may be associated with enhanced breastfeeding duration, signifying important benefits for both infant and maternal health.

Infant Protection

Several studies of mother–infant sleep behavior have now documented how routinely bed-sharing and breastfeeding dyads sleep in close proximity with a high degree of mutual orientation (facing one another) and arousal overlap (waking at the same time; see McKenna et al., 2007, for a comprehensive review). In recent years, these studies have been replicated in a variety of settings, and breastfeeding dyads have been observed displaying consistent bed-sharing behavior, regardless of whether they slept in a narrow hospital bed, in a full-size

bed in a sleep lab, or at home in beds ranging from twin to king sized (Baddock, Galland, Bolton, Williams, & Taylor, 2006; Ball, 2006; Young, Fleming, Blair, & Pollard, 2001). Mothers sleep in a lateral position, facing their baby, and curled up around the baby. Babies, positioned level with their mothers' breasts, sleep in the space created between the mother's arm (positioned above her baby's head) and her knees (drawn up under her baby's feet; Baddock et al., 2006; Ball, 2006; Richard, Mosko, McKenna, & Drummond, 1996; Young et al., 2001). The cumulative results of these studies provide a robust understanding of breastfeeding-related bed-sharing behavior and suggest that mothers' characteristic sleep position represents an instinctive behavior on the part of a breastfeeding mother to protect her baby during sleep (Ball & Klingaman, 2007). Although this behavior would have evolved in a very different sleep context than one adorned with Western beds and bedding, the principle of infant protection is no less effective. When breastfeeding mothers sleep with their babies, they construct a safe space in which the baby can sleep constrained by their own body, protected from potentially dangerous environmental factors—be they predators, cold weather, the suffocation hazards of quilts and pillows, or the overlaying risk of bed partners. This could therefore be characterized as an ancient infant care practice that is being played out in a new cultural environment (the Western sleep environment).

Hazardous Sleep Environments

The contemporary Western sleep environment in which mother–infant sleep contact occurs has been presumed to be hazardous to infants in terms of overheating and suffocation or rebreathing. Studies of the physiological effect on infants of sleep contact have been conducted by several researchers. Tuffnell, Petersen, and Wailoo (1996) reported that infants sleeping in contact with their mothers had an average core temperature 0.1°C higher than the average for lone-sleeping infants; other researchers have confirmed that while bed-sharing

babies are generally warmer than cot-sleeping babies, they maintain a stable core temperature and are not overly heated (Baddock, Galland, Beckers, Taylor, & Bolton, 2004).

Physiological studies have also investigated the effects of airway covering during bed-sharing. In a study of 40 regularly bed-sharing parents and infants and 40 age- and season-matched cot-sleeping infants aged 0 to 6 months, Baddock, Galland, Taylor, and Bolton (2007) found that 80% of infant head-covering episodes resulted from adult positional changes during sleep, and that 68% of uncovering of infant faces occurred by intentional and unintentional parental clearing of the covers, with infants clearing their own faces in 32% of cases (Baddock et al., 2007). In the Durham sleep lab, we also found that babies experienced more airway covering by bedding when bed-sharing than when sleeping in a cot, but that this airway covering did not compromise infants' ability to maintain normal levels of circulating oxygen, even when airway covering by bedding was prolonged (Ball, 2009). In the case of compromised oxygen supplies, it would be expected that infant heart rate would increase in order to more efficiently circulate available oxygen around the tissues. In the present study, airway covering was not associated with significantly lower oxygen saturation, nor with significantly increased infant heart rate, and although bed-sharing infants were frequently observed to have their airways covered, they also frequently got uncovered, sometimes as a consequence of the infant's own actions, but more commonly as a consequence of parental conscious or unconscious intervention. This study also found no evidence that sharing a bed with nonsmoking parents who were not under the influence of alcohol or drugs was a suffocation or compression hazard to a sleeping infant (Ball, 2009), and Sawcenko and Fleming (1996) reported that infants awoke or removed themselves from any potential rebreathing CO₂ situation encountered during bed-sharing. These studies indicate that Western adult sleep environments may not be as hazardous to bed-sharing babies as is sometimes presumed.

Sleep Architecture and Sudden Infant Death Syndrome

In the 1980s, 2 to 4 infants per 1,000 died suddenly and with no explanation (classified as sudden infant death syndrome [SIDS]) in Western industrialized countries (Guntheroth, 1989). In many Asian societies, even in industrialized populations such as Hong Kong and Japan, SIDS deaths occurred at a fraction of the rate found in the West (Lee, Chan, Davies, Lau, & Yip, 1989; Watanabe et al., 1994). McKenna (1986) suggested that the Western NICP of solitary infant sleep meant that infants were in an environment for which they were not designed biologically, were lacking the physiological regulatory effects of the mother's body, and were therefore at increased risk for SIDS (see McKenna, Ball, & Gettler, 2007, for an overview). McKenna suggested that solitary sleeping infants were deprived of sensory stimuli that could induce infant arousals. Without them, he hypothesized, infants born with deficits may more easily experience a breathing control error during sleep such as the kind suspected to be involved in SIDS. One testable prediction from this hypothesis was the expectation that maternal sleep contact would affect infant sleep states by increasing arousal opportunities and preventing long periods of deep sleep. In examining the differences in sleep architecture between infants sleeping alone and in contact with their mothers, Mosko and McKenna found that when bed-sharing, both mothers and infants experienced significantly more light sleep and less deep sleep than when sleeping separately, and that infants experienced significantly more arousals per hour of sleep when bed-sharing than when sleeping alone. Mosko et al. (Mosko, Richard, & McKenna, 1997; Mosko, Richard, McKenna, & Drummond, 1996) have argued that these features of a shared sleep experience could serve to minimize the occurrence of long periods of consolidated sleep from which infants with deficient arousal mechanisms may have difficulties in terminating prolonged apneas. Mosko et al. (1996) also suggested that during the crucial period when infants are most vulnerable to SIDS, mother–infant sleep contact may assist in consolidating the

integration of the neural mechanisms that underlie the arousal response. While further research is required in this area, the finding that transient arousal frequency was higher among routinely bed-sharing infants than among infants who routinely slept alone supports the notion that practice has a sustained impact on arousability. To date, however, epidemiological studies have only found a protective effect for SIDS and room sharing (cosleeping), and not bed-sharing. The novel infant care practice of encouraging long unbroken periods of sleep in young infants (e.g., sleep training) would therefore be a hazardous practice, particularly for infants with inbuilt arousal deficiencies.

Some authorities suggest that parent–infant sleep contact is a questionable practice that should be abandoned by parents and discouraged by health professionals due to concerns regarding risk of SIDS and/or accidental death (e.g., Ateah & Hemelin, 2008; Byard, 1994; Weale, 2003). Such recommendations acknowledge little or no value in mother–infant sleep contact and are based on case-control studies of SIDS or accidental infant deaths. Babies sleeping prone, parental smoking, poverty, and young maternal age are all well-known factors that are associated with an increased risk of unexpected infant death (Fleming, 1994), with many NICPs being implicated. However, estimates of the relative risk of SIDS in the context of bed-sharing vary widely. Assessments of the impact of bed-sharing on SIDS risk in the United Kingdom range from no increased risk to babies of nonsmoking parents to a 12-fold increase for infants sharing a sofa for sleep with a parent who smokes (Blair et al., 1999). The picture is obscured because studies use different criteria to define bed-sharing (e.g., Carpenter et al., 2004; Hauck et al., 2003; Tappin et al., 2005), have produced a confusing array of statistics that cannot easily be compared (see Côté, 2006; Horsley et al., 2007), and have conducted multivariate analyses in a nonsystematic manner (Matthews, McDonnell, McGarvey, Loftus, & O'Regan, 2004). These issues make it difficult to ascertain the truly risky elements of bed-sharing. Furthermore, SIDS case-control studies consistently

ignore infant feeding type in calculating relative risks associated with bed-sharing. Until more appropriate data are collected, it is impossible to ascertain whether breastfeeding-related sleep contact between mothers and babies confers a reduction or an increase in SIDS risk. However, it is unlikely that any potential risk would be of great magnitude (see Leduc & Camfield, 2006) given that breastfeeding is associated with a reduced SIDS risk compared to formula feeding in several studies (e.g., Hauck et al., 2003; Hoffman, Damus, Hillman, & Kongrad, 1988; Vennemann et al., 2009).

With regard to other bed-sharing risks, babies of breastfeeding mothers appear to avoid the presumed hazards of sleeping in adult beds (e.g., suffocation, overlaying, wedging, entrapment; Nakamura, Wind, & Danello, 1999), due to the presence and behavior of their mothers and as a result of their own agency (see earlier). We have observed the “protective sleep position” among first-time mothers sleeping with their newborn on the first night of life (Ball & Klingaman, 2007), and we have documented differences in behavior between breastfeeding and nonbreastfeeding mothers when sleeping with their babies (Ball, 2006). In the latter video study, nonbreastfed infants were generally placed high in the bed, at parental face height, and positioned between, or on top of, parental pillows. In contrast, breastfed babies were always positioned flat on the mattress, below pillow height and level with the mother’s chest. Nonbreastfeeding mothers spent significantly less time facing their baby and in mutual face-to-face orientation than did breastfeeding mother–baby pairs, and they did not adopt the “protective” sleep position with the same consistency (Ball, 2006).

The patterning of these differences is consistent with the physiological mechanisms mediating maternal and infant behavior, in that breastfeeding mothers experience a hormonal feedback cycle, which promotes close contact with, heightened responsiveness toward, and bonding with infants in a way that is different among mothers who do not breastfeed (Uvnas-Moberg, 2003). The implication here—that breastfeeding mothers and babies sleep together

in qualitatively and significantly quantitatively different ways than do nonbreastfeeding mothers and babies—suggests that epidemiological studies of bed-sharing that have not considered feeding type as a variable for matching cases and controls may have drawn inappropriate conclusions in assessing risk factors associated with bed-sharing, and the criticisms of breastfeeding-related bed-sharing may be unfounded.

Over the past decade, recognition of the evolved needs of mothers and babies during childbirth and the immediate postpartum period have become incorporated into a new cultural environment NCE-3, well established in European hospitals and emerging in the United States in the form of the UNICEF Baby-Friendly Hospital Initiative, that goes some way toward redressing some of the NICPs established in the contexts of NCE-1 and -2. Mother–infant skin-to-skin contact immediately following delivery, encouragement of breastfeeding, and 24-hour rooming-in provide conditions that are closer to those our evolved physiology might expect, but our research shows that this is just one step in the right direction, and there is still further progress to be made.

Conclusion

It would be unrealistic to believe that in the 21st century postindustrial world we can duplicate the conditions of our ancestral evolved environment; however, there is a growing recognition that elements of our ancestral environments that are crucial to the operation of our mammalian, primate, and hominin physiology can be emulated within a contemporary environment of cultural adaptation. Breastfeeding mothers do this instinctively when they sleep in close contact with their infants, encouraging them to feed at will, supporting their physiological development with their own bodies and behaviors, and allowing their infant's chronobiology to unfold according to the infant's individual schedule. It is also apparent as a result of our research that infants are not the only component of the dyad to be affected by

environments of recent cultural change, with the impact of sleep contact on maternal physiology (lactation) also having profound effects.

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Figure 9.1. Environments of evolutionary adaptedness (EEAs) and recent cultural change affecting mother–infant relationships and nighttime care. ERCC = environment of recent cultural change; NICP = novel infant care practice.

Figure 9.2. Definitions of bed-sharing and co-sleeping. (no caption)